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Automated Cracked Wheel Detection System Overview

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SUMMARY

The Association of American Railroads' continuing effort to improve freight railroad safety through its Strategic Research Initiatives Program has led to a new contact ultrasonic inspection approach. The resulting system demonstrated its ability to detect cracks in moving railcar wheels. It is expected that by implementing this inspection technology into revenue service wayside operations, the number of wheel failures resulting from cracks can be reduced, providing a higher level of safety and efficiency during railroad operations.

The Automated Cracked Wheel Detection (ACWD) system, which was developed under a partnership between Transportation Technology Center, Inc. (TTCI) and DAPCO Industries, is the first inspection system of its kind and was constructed to withstand a variety of environmental conditions. Since its installation at the Transportation Technology Center (TTC) in February 2006, the system has been exposed to and operated in a number of environmental conditions such as strong winds, snow, rain, hail, tumbleweeds, sand, and wildlife. It is designed to operate in a temperature range from -10 to 140 degrees F.

This ultrasonic inspection system is fully automated and provides inspection of each wheel while a train is moving on the track. Previous approaches required manual inspection, using handheld portable ultrasonic flaw detectors that would require approximately 15 to 20 minutes to inspect each wheel and approximately three weeks for a dedicated two-person crew to inspect a 105-car train. The ACWD system, operating at approximately 5 miles per hour, provides complete tread inspection for one side of a 105-car train in about 13 minutes.

Several trains were inspected by the ACWD system at TTC in 2006. One of the trains used to qualify the ACWD system was a 13-car test train with 36-inch and 38-inch diameter wheels. Wheels identified by the inspection system as containing possible flaws were characterized using a portable handheld ultrasonic inspection technique. Eleven wheels were identified by the system for possible flaws and were evaluated using this approach. The results showed that the four wheels containing artificial defects and wheels containing shattered rim cracks were repeatedly detected by the system.

TTCI has coordinated with the system manufacturer and identified system modifications that will assist in providing full tread coverage and required calibration to minimize false calls and assure reliable and repeatable automated wheel inspections in service. Industry demonstrations of the ACWD system in 2006 have resulted in at least two major U.S. railroads considering installation of these systems in 2007.

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INTRODUCTION

TTCI partnered with DAPCO Industries in 2005 to manufacture a wayside inspection system that inspects all the wheels on one side of a train as it moves along the track at 4 to 5 miles per hour (mph). This unique ACWD system has been installed at TTC near Pueblo, Colorado. The ACWD system provides the industry with the capability to detect cracks in wheels on a moving train while it is still in service.

Until now, the main option for railroads has been to inspect wheels for defects manually using labor-intensive techniques. Currently it takes approximately 15 to 20 minutes to ultrasonically inspect a wheel using manual portable handheld ultrasonic equipment. Inspection time also depends on the logistics in place to spot the wheels in the train.

To inspect a 105-car 4-axle train (840 wheels), at 15 minutes per wheel, it would take around 210 man-hours to inspect all the wheels in the train. Using the manual inspection approach takes a dedicated two-man crew about three weeks to complete a 105-car inspection. The ACWD system at TTC was able to perform a wheel inspection on one side of a 105-car train in approximately 13 minutes.

Removing freight cars from service to perform nondestructive inspection for internal and tread defects in wheels, on a regular basis, is not a viable option, but neither is having derailments (albeit, relatively few) due to broken wheels. It is expected that by implementing ACWD systems into revenue-service operations, wheels would then be inspected in a wayside environment.

SYSTEM OVERVIEW

The Association of American Railroads' continuing efforts to improve freight railroad safety through its Strategic Research Initiatives Program has led to a conventional ultrasonic inspection approach that has demonstrated its ability to detect cracks in moving railcar wheels.

The ACWD system prototype uses a conventional ultrasonic approach to dynamically inspect railroad wheels as a train rolls across the system at approximately 5 mph. The wayside system includes four test stations allowing for complete 100-percent ultrasonic inspection of railroad wheels for shattered rim and tread cracks on each of four wheels on one side of each passing railroad car.

Pattern recognition provides real-time assessment and reporting of flaw type, size, and location in and across the tread and rim of the wheel. Sensitivity has been focused toward detection of those shattered rim and tread cracks 0.5-inch long or greater. Figure 1 shows a shattered rim crack (SRC) that has broken open to the tread surface. The ACWD system is designed to detect flaws before they get to this point.

Figure 1. Shattered Rim Crack

To provide access to the wheel tread, flange bearing rails were installed that allow the inspection heads to remain in full contact with wheel treads as the train passes through the test station. Figure 2 shows the inspection heads that have been designed to track each wheel tread vertically, laterally, and longitudinally using rotary trim sensors at each test station. The inspection heads have a spring suspension on each end to allow for continuous inspection, whether the inspection head is on a leading or trailing position with respect to the wheel. The length of each test station has also been designed to accommodate the inspection of railroad wheels up to 42 inches in diameter.

Figure 2. Inspection Heads

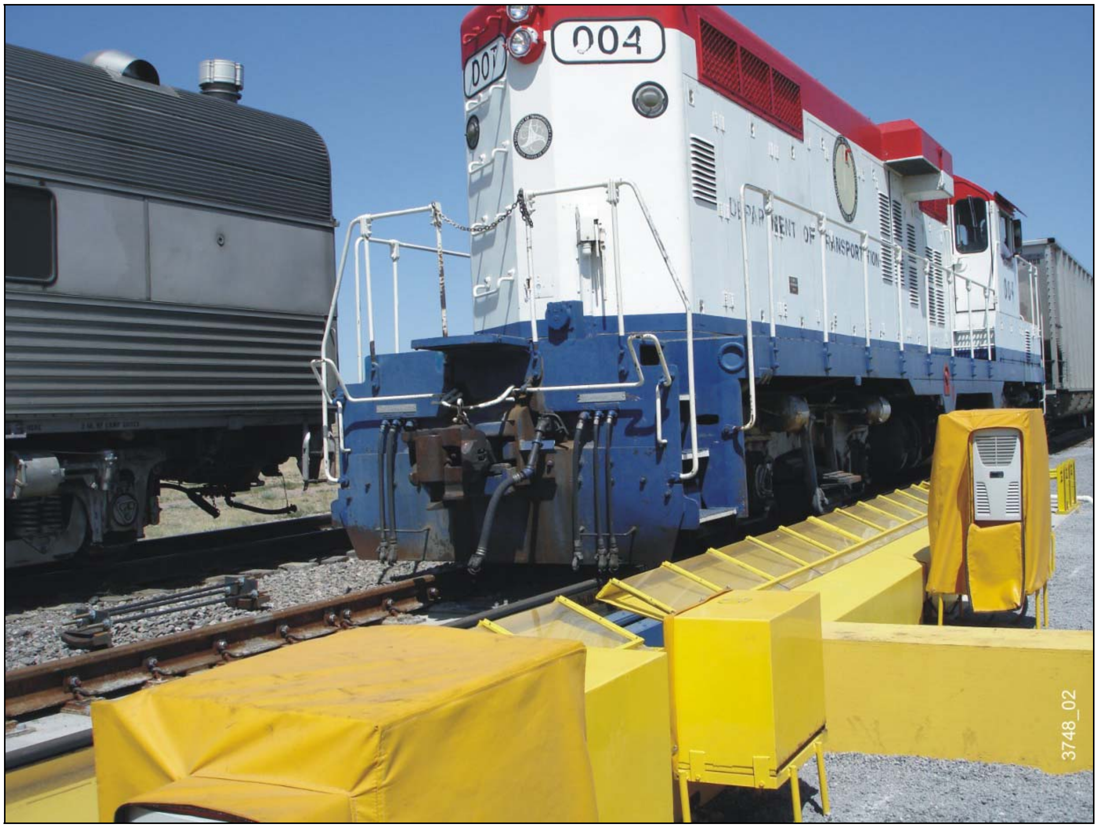

Figure 3. Train over the ACWD Test Site

The ACWD system was constructed to withstand a variety of environmental conditions; e.g., dust, dirt, and other trackside debris in a wayside environment. Since its installation at TTC in February 2006, the system has been exposed to and operated in conditions of strong winds, snow, rain, tumbleweeds, and hail. This system is designed to operate in a temperature range from -10 to 140 degrees F.

SYSTEM QUALIFICATION

There have been several trains inspected through the ACWD system: (1) a 13-car TTCI test train, (2) a 64-car heavy axle load (HAL) (315,000-pound cars) train that operates at the Facility for Accelerated Service Testing (FAST), and (3) a 105-car Union Pacific (UP) unit train (empty 286,000-pound cars). Figure 3 shows a test train proceeding through the system.

Initial evaluations were performed primarily to validate the system and ensure that each wheel on one side of the test train was dynamically inspected. Results were used to calibrate the system for future testing. The test with the HAL train at FAST was conducted to verify the reliability of the system with repeated runs using a longer consist.

Testing with a UP unit train was performed not only to inspect the wheels, but also to demonstrate that the system could reliably perform with a mile-long unit train operating through it. Calibration cars were set up on each end of the train to document system calibration at the beginning and end of each run. Wheels in the UP consist were in various conditions. Visual inspection of the wheels showed that around 50 percent looked to be in good condition. None of the wheels were condemnable, although about 25 percent had rim thicknesses of 1 inch or less. Twenty percent had some spalling on the tread, and 5 percent of the wheels displayed edge chipping. A few of the wheels had burn marks on the tread and some had thin flanges. Generally, the state of the wheels was typical for revenue service.

Wheels identified by the inspection system as containing possible flaws were characterized using a portable handheld ultrasonic inspection technique to verify wheel condition. Eleven wheels were evaluated using this approach. The results showed that four of the wheels alarmed by the system were due to geometry, as these wheels contained rim thicknesses of 1 inch or less, and the inspection threshold was set greater than 1 inch, which produced the false positives. Three of the wheels contained wheel spalls at a depth of approximately 0.25 inch below the tread running surface. The other four wheels contained SRCs that were ultrasonically sized to be approximately 0.25-inch long, 0.25-inch wide, and 0.40-inch deep. All of the SRC indications were at the tapeline of the wheels.

Qualification tests assisted in identifying modifications to the system that could improve inspection reliability. The qualification train contained all of the cars from the initial test train with seven additional cars from the UP unit train. Modifications made to the system before operation included installation of:

- A rotation sensor to replace the ultrasonic positioning transducers to improve the tracking between the wheel and inspection head
- A 3/8-inch steel angle over the south guardrail designed to push the wheels farther out over the system
- An air actuator to push the transducer towards the track with a contact point between the carriage head and the wheel that keeps the transducer shoe in a consistent placement with the wheel
- A switch point protector at the entry of the flange bearing rail to help push the wheels away from the guardrail

After the modifications to the ACWD system were made, a calibration wheel containing 0.25-, 0.50-, and 1-inch flat bottom holes (FBH) was added to the test train to determine the system's repeatability. Several test runs were made, and all three FBHs were detected during each run. The pattern recognition system was also able to distinguish between the sizes of the FBHs by observing the number of ultrasonic hits (counts) across each of the artificial flaws. Figure 4 shows the improvement in repeatability from a comparison of runs made during initial testing performed in March 2006, and the qualification testing performed in August 2006.

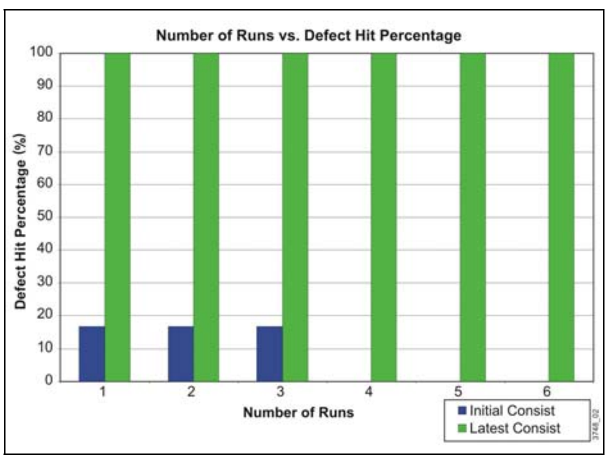

Figure 4. Repeatability Comparison

Modifications to the ACWD system, targeted to increase reliability and decrease false calls, are being coordinated between TTCI and the system manufacturer. Figures 5 and 6 show one such modification to increase inspection coverage by adding more transducers.

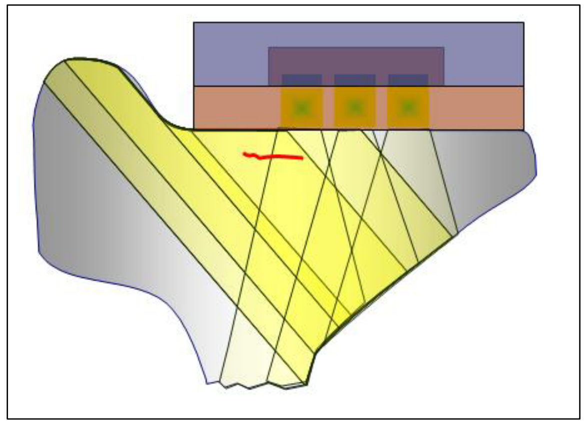

Figure 5. Current Ultrasonic Tread Coverage

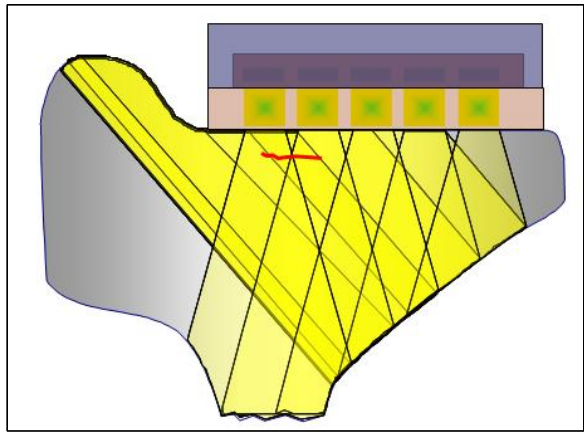

Figure 6. Modified Ultrasonic Tread Coverage

CONCLUSIONS

The ACWD system installed at TTC has successfully demonstrated the ability to inspect wheels on a moving train. The increase in efficiency, from using this inspection approach, is considerable when comparing previous manual inspections to the automated approach provided by this system. Decreases in inspection times go from weeks for the manual system, to minutes by the automated system. Industry demonstrations of the ACWD system in 2006 have resulted in at least two major U.S. railroads considering ACWD installation in 2007.

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2. Garcia, Greg, Dane Hackenberger, and John Tunna. March 2001. "Ultrasonic Wheel Crack Detection System Update." *Technology Digest* TD-01-005. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.